Sálas y Gómez: A natural pollen trap in the Pacific and its significance for the interpretation of island pollen diagrams

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Introduction

Those who attempt to reconstruct the history of the vegetation on remote oceanic islands by the technique of palynology have always been aware of the possibility that their results could be vitiated by pollen transported long distances through the atmosphere, from other islands or from distant continents. This possibility is not altogether fatuous. In a famous experiment using a vacuum cleaner, Erdtman (1952) caught a single grain of *Pinus* on a ship in mid-Atlantic. Surface samples of peat from Tristan da Cunha yielded a few grains of *Nothofagus*, which must have travelled 4,000 km from South America (Hafsten 1960). This genus even contributed pollen to Marion Island, over 7,000 km from the source area (van Zinderen Bakker, 1974). It is claimed that *Casuarina* pollen found in New Zealand had travelled there from Australia (Close *et al.*, 1978).

On Easter Island, Selling (in Heyerdahl & Ferdon, 1961) explained occasional *Ephedra* grains as originating in South America, and Flenley *et al.* (1991) reached the same conclusion. In the case of Easter Island, the possibility that other taxa of the fossil pollen had originated in south America was raised by several people in discussion, especially in the case of the pollen type similar to that of *Jubaea chilensis*, the Chilean wine palm. Although the Easter Island palm pollen was present in such quantities as to make this origin highly improbable, there seemed to be no opportunity of obtaining empirical evidence against this idea.

This may now have changed, thanks to the action of one of the authors, GV. In August 1992, he was able to land by helicopter on the tiny islet of Sálas y Gómez, 415 km E.N.E. of Easter Island at latitude 26°25'S, longitude 105°21'W. The island (Fig. 1) is a basalt reef about 700 m long, rising to only 70 m height. Most of the land is bare rock swept by storms waves and salt spray. The island bears only four species of vascular plants: *Portulaca* sp., *Tetragonia expansa* Murr, *Boerhaavia diffusa* L. and *Asplenium obtusatum* (Scottsberg, 1956). In one place there is a small rock basin which may hold fresh water in wet weather. At the time of GV's visit it was dry but contained a brown sediment. GV was able to extract a short core from this sediment.

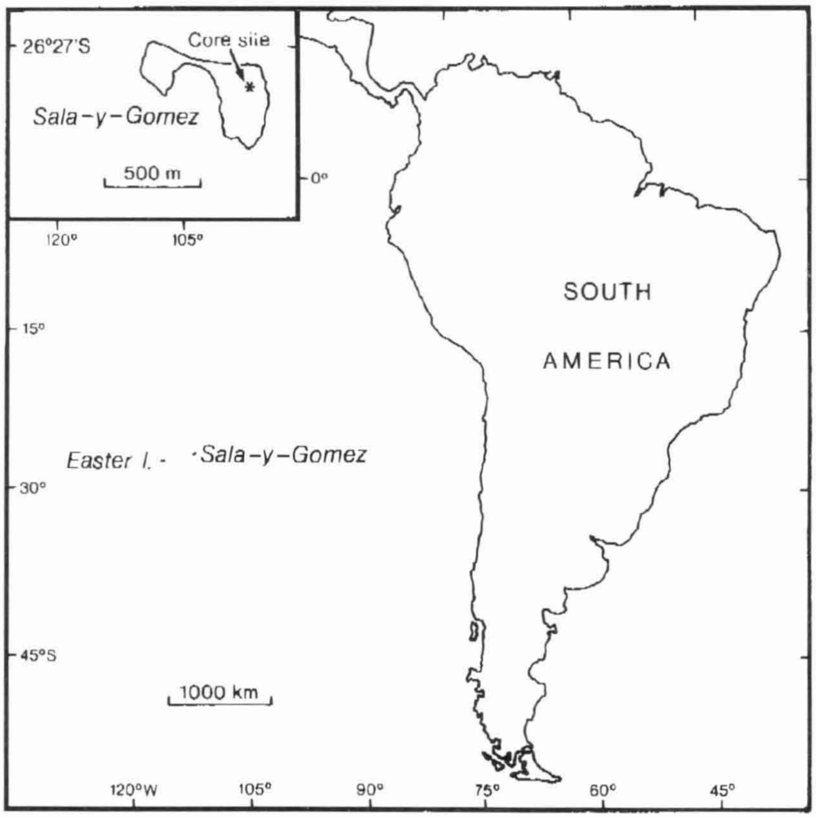

Figure 1. Location and map of Sala-y-Gomez, showing the position of the coring site.

Field Methods

A plastic half-tube, diameter c.30 mm, was first washed (on Easter Island) with abundant running water, and then wrapped in paper. On the site, the deepest sediment was discovered by digging, and the tube was then hammered in close to that point. The tube was then dug out. Paper was inserted in the top to prevent core movement, and the tube was carefully wrapped. After returning to Easter Island, the top of the tube was sawn off, and the core, 35 cm long, was wrapped for shipment to Massey University.

Laboratory Methods

The core was stored at Massey University at c.5°, wrapped in polythene sheet. On examination the sediment appeared to consist mainly of grey-brown silt. Samples of volume 2 cm^3 were removed for analysis from the following depths: 0-1 cm, 1-2 cm, 2-3 cm, 3-4 cm, 4-5 cm, 5-6 cm, 7-8 cm, 16-17 cm, 24-25 cm and 34-35 cm. To each sample a tablet containing a known number of *Lycopodium* spores was added, to permit calculation of absolute pollen frequency (Benninghoff 1963; Stockmarr 1971). The samples were then subjected successively to 5% hydrochloric acid, acetolysis (acetic

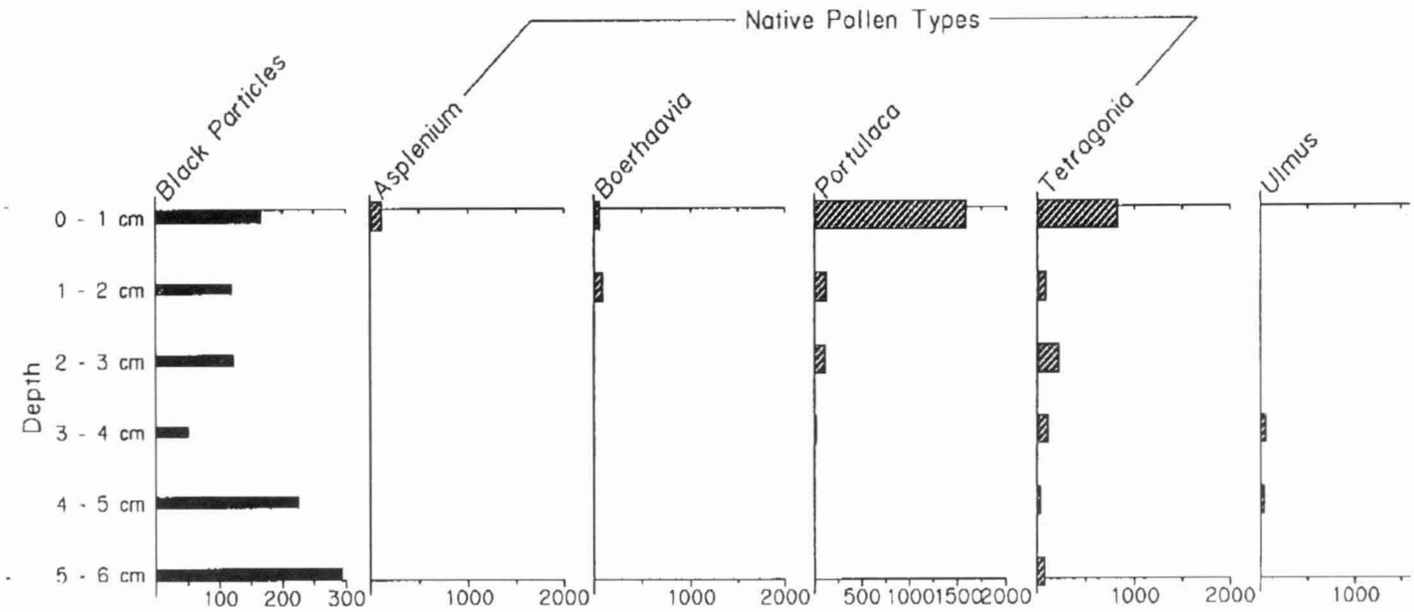

Figure 2. Pollen counts from the pond on Sala-y-Gomez, expressed in absolute terms.

anhydride and conc. sulphuric acid), sodium pyrophosphate (thrice), hydrofluoric acid (5 minutes boiling in 40% solution), oxidation (sodium cholorate and hydrochloric acid) and decantation, using the methods described by Faegri & Iversen (1975) and Moore & Web (1978). In addition, the topmost samples (down to 8 cm) were sieved at 10 µm. This was not practicable with the other samples because of their low pollen content. All samples were mounted in silicone oil and two to four slides made from each sample.

The slides were examined at x400 on an Olympus photomicroscope, but only the uppermost samples (down to 6 cm) contained enough pollen for a proper count. For the other samples, prolonged scanning at a lower power was used. All pollen seen was identified, using the reference slides prepared from specimens collected from Sálas y Gómez by GV during a previous visit. Black opaque particles larger than 10 µm were also counted.

Results

The results are shown as raw counts in Table 1. Knowing the number of *Lycopodium* spores in each tablet (13,911 ± 308 in this case) and applying a proportional calculation, it is possible to express the results from the top six samples in absolute terms (grains/cm^3) and this is done in Fig. 2. As the time-depth represented by the core is unknown, it is impossible to express the results in terms of pollen influx (grains/cm2/annum).

Discussion

Of the black particles found abundantly in every sample, many had regular shapes, often square, and few had the appearance of charcoal or carbonised plant material. It is therefore concluded that these objects are either iron pyrites crystals or dark minerals (possibly of the pyroxene group), weathered out from the basalt. Their abundance reflects the predominately inorganic composition of the sediment.

The fact that the core is mainly inorganic suggests that biological productivity is low in the basin, and sedimentation therefore slow. The fact that only the top 3 cm contains significant numbers of pollen grains suggests that the sediment dries out periodically, leading to oxidation of most pollen grains in the older sediment. If that is so, the top 3 cm may represent the time since the last major dessication. It is likely, however, to represent many years, if sedimentation is slow. We therefore argue that the surface (0-1 cm) sample represents the catch of a natural pollen trap in the Pacific, over several years.

The large differences in the counts for the four native taxa in the 0-1 cm sample are attributed to variations in the abundance and location of the parent plants, and to the variation in production, dispersal and taphonomy of their pollen grains and spores. The declining counts between 1 cm and 4 cm are believed to represent the results of progressively greater amounts of oxidation.

The values in the top sample for the individual taxa in grains/cm3 are not unreasonable, although the values for *Portulaca* might seem rather high for what is probably an insect-pollinated species. The explanation is possibly that the plant grows near to the basin and that, in the absence of trees, wind speeds are sufficient to carry any grains into the basin. Rain-splash and overland flow may also carry pollen into the basin, especially over a rocky terrain.

The total number of pollen grains per cm^3 in the 0-1 cm sample is 16,858. The specific gravity of the sediment is probably between 1.0 (water) and 3.0 (rock), giving values between c.17,000 and c.5,000 for the number of grains per gram. These are also unsurprising figures. Traverse (1988) gives figures varying between 1,000/g for seidments from the

TABLE 1
PALYNOLOGY RESULTS FROM SALA-Y-GOMEZ

Depth cm	Portulaca	Tetragonia	Boerhaavia	Asplenium	Coprosma	Cyperaceae Scirpus comp.	Gramineae	Ulmus	Lycopodium (added)	Black particles
0-1	269	14	1	2					118	167
1-2	40	3	3						226	120
2-3	34	7							211	123
3-4	4	2						1	120	50
4-5		1						1	171	226
5-6	1	3							247	294
6-7									A	A
7-8									A	A
8-9	2				1				A	A
16-17									A	A
24-25									A	A
34-35		1				1	1		A	A

A = Abundant

Great Bahama Bank and 50,000/g for silts from a minor delta. It is interesting that only native taxa occur in the top three samples, but that some non-native taxa occur in the lower samples where oxidation is believed to have destroyed most of the fossil pollen.

The taxa not native to Sálas y Gómez are *Coprosma*, *Cyperaceae*, *Gramineae* and *Ulmus*; a total of five grains in the 392 grains counted (excluding the added *Lycopodium*). *Ulmus* is a northern hemisphere genus, and *Coprosma* is not found native east of Tahiti (van Balgooy 1971). *Cyperacaea* and *Gramineae* are ubiquitous. All these grains could have arrived by long-distance dispersal to Sálas y Gómez. But there are problems with this explanation. It seems extremely odd that these exotic grains should be so differentially favoured by the oxidation process as to equal or even exceed the native taxa in frequency. Also, *Ulmus* has a heavy grain which is not given to long distance travel (Tauber 1965), and the other pollen taxa, not being from trees, are released near the ground, giving them little chance to reach the upper atmosphere for long-distance travel.

An alternative hypothesis is some kind of contamination. One possible mechanism for this is suggested by the fact that all these taxa grow abundantly on Massey University campus. Although our preparation laboratory is reasonably free from aerial contamination, this core was prepared in late winter when these taxa could have been in flower. Another possibility is that some of the contaminating taxa were present in the *Lycopodium* tablets. Usually, however, the only contaminant in these is *Artemisia* (observation by JRF), which was not found in this case. Filtered air has now been installed in our laboratory. This should remove virtually all pollen grains and prevent further contamination.

There is no way of deciding with certainty between the long-distance dispersal and the two contamination hypotheses, but the balance of the evidence appears to favour contamination in the laboratory. In any case, no taxon which could have come only from South America was found.

A more positive line of discussion is to compare the 0-1 sample with surface samples from the crater lakes/swamps on Easter Island (Flenley *et al.* 1991). A glance at these will show that they are dominated by *Gramineae*, fern spores and *Cyperaceae*, and contain no *Portulaca* or *Tetragonia*. In other words, each site on Easter Island or Sálas y Gómez is reflecting the local vegatation.

Conclusion

Although *Jubea chilensis* is now a less common tree than formerly, it still occurs in substantial numbers in Chile (Heusser 1971). The absence in the Salas y Gomez samples of the pollen of this and of any other distinctly South American taxa suggests that long-distance pollen transport from South America into the Pacific is rare, at least in sub-tropical latitudes. If the hypothesis of laboratory contamination is accepted, then the same is true of transport from the S.E. Asia-New Zealand region.

It is therefore concluded that long-distance transport of pollen in the Pacific region may occur, but it is probably a rare phenomenon, which is unlikely to interfere significantly with the interpretation of island pollen diagrams.

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Pacific Ocean Area Numeral Names Compared

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When I traveled to Peru last winter on my way to Rapa Nui, I noticed that the names for numbers from one-to-ten in the ancient South American languages, Aymara and Quechua, had no relationship to any Polynesian languages. This was another piece of fortifying evidence that the language and people of Rapa Nui did not originate from South America.

I worked up a table that shows the conformity or degrees of non-conformity of selected island languages across the Pacific. This is not a flashpoint of information to a Pacific scholar. It is, however, corroborative data for a neophyte Rapanuiphile or student of the Pacific. (see page 21)

The names of numerals in the languages of the Polynesian Bloc are conformal; those of Indonesia, Melanesia and Micronesia in the west are somewhat less-conformal; and those in the east (South America) are non-conformal. Spanish is not included since it was a relatively newcomer; introduced at the time of Spanish conquest c. 1540.

During my research, I found that similar language comparisons had been made by Sheldon Dibble (*A History of the Sandwich Islands,* 1843) and Abraham Fornander (*An Account of the Polynesian Race - Its Origins and Migrations,* 1877). However, they did not include any South American languages.

The distance between the farthest islands, Indonesia (Sulawesi) and Rapa Nui is about one-third the circumference of the earth (8,500 statute miles). The distance from Rapa Nui to the South American coast is about 2,300 statute miles.

The Polynesian migration dates are from the September 1995 National Geographic Society's Double Map Supplement of Hawaii and Rediscovering Hawaii. A map inset (Voyages of Discovery) fine-tunes previous NGS migration data used over 20-years ago (December 1974).

The Aymara and Quechua are South American Indian tribes who, from earliest times, have occupied the central Andean highlands around the Lake Titicaca Basin in southern Peru and western Bolivia. They were part of the Inca empire until the time of the Spanish conquest. The Quechua language even prevails today in Peru, Bolivia, Equador, Chile and northwest Argentina. It has been named an official language by Peru and is estimated to be spoken by eleven million people.